particular, the corresponding maxima and minima do not differ by more than 2 or 3 min during the first hour of observations. This analysis explains the three apparently different modes of recovery reported by Charnley *et al.*[1] in different leaves of this species.

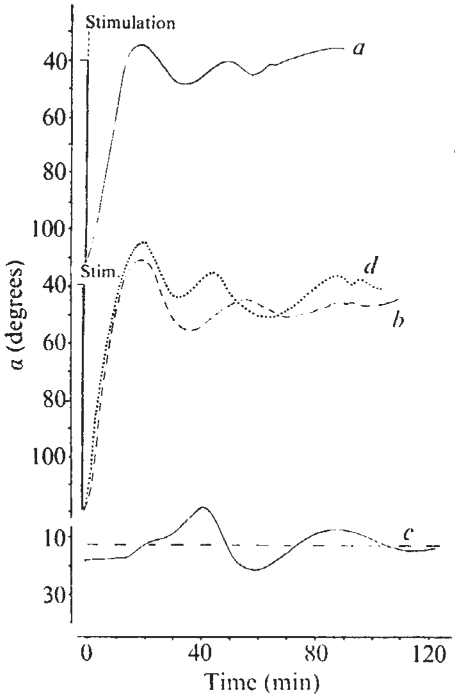

Fig. 3 Components intervening in the recovery process. *a*, Experimental temporal variation. *b*, Temporal variation due to seismonastic movement without geotropic effect. *c*, Temporal variation due to geotropism alone. *d*, Theoretical temporal variation obtained by adding curves (*b*) and (*c*).

These modes can be obtained by a simple relative shifting of curves (*b*) and (*c*), which has been proved experimentally.

I thank Professor P. Gavaudan, Drs Charnley and Perrin for advice and the CNRS for support.

GABRIEL ROBLIN

Laboratoire du Chronophytotron, Station biologique de Beau-Site, 86000 Poitiers, France

1 Charnley, T., Perrin, R., and Porter, D., *Nature*, **257**, 389–390 (1975).
2 Brunn, J., *Beitr. Biol. Pfl.*, **9**, 307–358 (1909).
3 Ruge, U., in *Catalogue Films Scientifiques* (Service du film de recherche scientifique, Paris, 1947–1948).
4 Aimi, R., *Bot. Mag., Tokyo*, **76**, 374–380 (1963).
5 Fondeville, J. C., thesis. Univ. Poitiers (1964).
6 Gavaudan, P., and Roblin, G., *C. r. Séanc. Soc. Biol.*, **165**, 162–166 (1971).
7 Bose, J. C., in *The Motor Mechanism of Plants*, 429 (Longmans, Green, London and New York, 1928).
8 Wallace, R. H., *Am. J. Bot.*, **18**, 288–307 (1931).
9 Roblin, G., thesis. Univ. Poitiers (1975).
10 Gavaudan, P., and Roblin, G., *C. r. Séanc. Soc. Biol.*, **163**, 743–746 (1969).

Crystal structure and Dirac's Large Numbers Hypothesis

TOWE[1] has raised what he considers to be a serious difficulty against Dirac's[2] Large Numbers Hypothesis. He claims that geological evidence weighs heavily against multiplicative creation. We point out here two serious flaws in Towe's arguments which invalidate his conclusion.

Towe claims that the measured equality of lattice dimensions between a 3×10^9-yr-old quartz crystal and a new quartz crystal weighs heavily against Dirac's multiplicative creation. Towe states that atomic distances in Dirac's theory vary like t^{-1}, t being cosmological time. Although it is true that atomic distances expressed in Einstein units do vary as t^{-1}, it is a conceptual error to use such a time dependence for comparison with measurement, since any observed value for distance is obtained with apparatus which measures only in atomic units.

In fact, Dirac's theory predicts that atomic distance scales formed from m (particle mass), e (particle charge), and h (Planck's constant) should not vary with t in atomic units, which are the ones to be used. Only the number of particles N, the gravitational constant G, and any quantity defined in terms of N and G (such as the radius of a star, or the orbit of a planet about a star) could depend on t when expressed in atomic units.

Even supposing that the lattice dimensions could vary with time, the only possible verification of this would be to perform the same measurement at two different times. The reason why measurements performed on two crystals at the same time must give identical results is simple. Both crystals are made of the same kinds of atoms with the same physical laws in effect—those laws which are valid at the time of measurement. Consequently, at any given time the lattice spacing for a given crystal structure must be the same regardless of whether the crystal is old or new; the past history of the crystal is irrelevant.

In point of fact, since lattice dimensions are expressed only in terms of m, e and h, which have no time dependence when expressed in atomic units (that is measurable units) Dirac's theory predicts that lattice dimensions do not change in time.

As mentioned repeatedly by Dirac[3,4], it is difficult to understand how the matter in very old rocks can have multiplied without disrupting their crystal structure. This is because N varies as t^2 ($M\simeq t^2$, because $M = Nm$).

Towe's experimental result that both the molecular weight and X-ray density of unit cells of the two crystals are equal tends to support the opinion that the new matter is not interstitial. This in no way constitutes a serious blow against Dirac's theory.

V. CANUTO
P. J. ADAMS
E. TSIANG

Institute for Space Studies, NASA, New York, New York 10025

1 Towe, K. M., *Nature*, **257**, 115 (1975).
2 Dirac, P. A. M., in *The Physicist's Conception of Nature* (edit. by Mehra, J.), 45 (Reidel, Dordrecht, 1973).
3 Dirac, P. A. M., *Pont. Acad. Commentarii*, **11**, No. 46 (1973).
4 Dirac, P. A. M., in *Theories and Experiments in High Energy Physics* (edit. by Kursunoglu, B., *et al.*), 443 (Plenum, New York, 1974).

TOWE REPLIES—Canuto, Adams, and Tsiang[1] are absolutely correct in pointing out that my crystal lattice spacing argument[2] regarding Dirac's multiplicative creation model is invalid. The lattice spacings of old and new crystals will indeed always appear the same. Nevertheless I cannot agree that no setback to Dirac's multiplicative creation hypothesis (in its present form) is incurred by the observation that there is a reasonable agreement between X-ray and pycnometrically determined densities in the minerals of the oldest rocks. If new atoms cannot be added as interstitials then they must be added to new unit cells external to and part of the existing crystal structures. About 40% additional atoms are required for crystals 3×10^9 yr old. In accommodating the added unit cells into existing rocks, any extensive deformation with accompanying phase changes (recrystallisation) must be avoided to prevent resetting the radioactive 'clocks'. The alternative to interstitials would thus seem to transcend conventional physics because in addition to the multiplicative creation of atoms with time ($Nm\simeq t^2$) it requires the simultaneous creation of the intercrystalline space ($V\simeq t^2$) to accommodate them. If this is accepted as a realistic alternative, then a rock and all of its crystals would be getting larger, resulting in a secular trend toward increasing grain size in older rocks. What inconclusive data there are[3] tend to support the opposite conclusion. Like Canuto's cosmological studies (in preparation), perhaps future petrographic studies can be designed specifically to deal with such an esoteric model of petrogenesis.

Smithsonian Institution Washington, DC 20560

1 Canuto, V., Adams, P. J., and Tsiang, E., *Nature*, **261**, 438 (1976).
2 Towe, K. M., *Nature*, **257**, 115 (1975).
3 Nanz, R. H., Jr, *J. Geol.*, **61**, 51 (1953).